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ABSTRACT

A study demonstrated the positive impact of school ownership of the Accelerated Reader (AR) technology-based literacy program on attendance and standardized test scores at a representative sample of 2,500 elementary, middle, and high schools. These schools were compared with approximately 3,500 schools of similar geographic and demographic characteristics that did not own the software. A comparative analysis of data revealed: (1) statistically significant evidence that, on virtually every subject test (including reading, writing, math, science, and social studies), a majority of schools that owned AR performed better than socioeconomically comparable non-AR schools; (2) a statistically significant majority of AR-owning schools also had higher attendance rates than their non-AR peers; (3) gains in academic performance increase with the length of time schools own AR--schools that have owned AR for 2 or more years are 59% more likely to show test performance above the median for their control group; (4) analysis of AR's effectiveness in different metropolitan settings indicates that AR is by far most influential in urban schools and in low socioeconomic environments; and (6) increased performance of AR-owning schools does not vary with the relative availability of microcomputers at those schools, indicating that the effect is not related simply to increased use of technology. Findings suggest that AR has a positive effect on student academic performance, especially for socioeconomically disadvantaged children in urban areas. Together with the results of previous Institute studies, this is compelling evidence that AR is an effective tool in stimulating increased reading, and that increased reading will lead to higher attendance rates and greater academic success. (Includes 18 notes and 6 tables of data.) (Author/SR)

ED 421 684

IMPACT OF THE ACCELERATED READER®

on Overall Academic Achievement and School Attendance

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CS 013 250

Impact of the Accelerated Reader® Technology-Based Literacy Program on Overall Academic Achievement and School Attendance

by Terrance Paul, Darrel VanderZee, Tom Rue, and Scott Swanson

Abstract

This study demonstrates the positive impact of school ownership of the Accelerated Reader (AR) technology-based literacy program on attendance and standardized test scores at a representative sample of 2,500 elementary, middle, and high schools. These schools were compared with approximately 3,500 schools of similar geographic and demographic characteristics that did not own the software. This analysis used data from Advantage Learning Systems, Inc. (publishers of AR), Quality Education Data, Inc., and state educational agency statistics.

A comparative analysis of this data produced the following results:

- *Statistically significant evidence that, on virtually every subject test (including reading, writing, math, science, and social studies), a majority of schools that owned AR performed better than socioeconomically comparable non-AR schools.*
- *A statistically significant majority of AR-owning schools also had higher attendance rates than their non-AR peers.*
- *Gains in academic performance increase with the length of time schools own AR. Schools that have owned AR for two or more years are 59 percent likely to show test performance above the median for their control group.*
- *Analysis of AR's effectiveness in different metropolitan settings indicates that AR is by far most influential in urban schools and in low socioeconomic environments.*
- *The increased performance of AR-owning schools does not vary with the relative availability of microcomputers at those schools, indicating that the effect is not related simply to increased use of technology.*

Based on these results, the report concludes that AR has a positive effect on student academic performance, especially for socioeconomically disadvantaged children in urban areas. Together with the results of previous Institute studies, this report provides compelling evidence that AR is an effective tool in stimulating increased reading, and that increased reading will lead to higher attendance rates and greater academic success.

Introduction

This was a large-scale study of the effectiveness of Advantage Learning Systems' Accelerated Reader technology-based literacy program. It was the fourth in a series of studies on reading completed by the Institute for Academic Excellence. Our objective was to determine whether the Accelerated Reader, which has been purchased by more than 32,000 schools nationwide, has a measurable, demonstrable effect on academic achievement and school attendance rates. The Accelerated Reader, or AR, is a program for literature-based reading practice in K-12 classrooms. As described below, AR helps teachers motivate students to read more books, while enabling teachers to evaluate, monitor, and record student progress. It provides continuous assessment and accountability for literature-based reading.

The Institute for Academic Excellence was founded in 1993 by Judith and Terrance Paul, creators of the Accelerated Reader and owners of Advantage Learning Systems. The Institute develops instructional systems to improve academic achievement in K-12 schools, and trains educators in implementing these systems. The Institute's Reading Renaissance program incorporates AR as a management and motivational tool.

The current study analyzed data from 6,149 Texas schools. Depending on whether they did or did not own the Accelerated Reader, the campuses were identified either as AR or non-AR schools. Each AR school was compared with a cohort of non-AR schools determined by the Texas Education Agency to be demographically similar to that particular AR school.

Data on academic achievement came from the Texas Assessment of Academic Skills (TAAS), an annual statewide testing program. We compared the TAAS pass rates of each AR school to the median pass rate of its non-AR cohort. The fundamental finding of this study is that the pass rates of AR campuses tended, with considerable statistical significance, to be above the median pass rates of their comparison cohorts.

The higher pass rates were not limited to reading scores. Analysis showed statistically significant differences for reading comprehension, writing, math, science, and social sciences; all results favored the AR schools over the non-AR schools. This implies that improved reading skills developed using the Accelerated Reader led directly to improved general academic achievement.

In addition to higher academic achievement, AR schools were likely to have higher attendance rates than their non-AR socioeconomic peers. Significantly, the probability of outstripping their peers rose in conjunction with the number of years since they had purchased the software.

Finally, while AR schools at every socioeconomic level outperformed their non-AR cohorts; the most significant results were for schools ranked low on the socioeconomic ladder — which is to say, AR was most successful where success counts the most.

Thus, this study indicates that the Accelerated Reader software has a measurable positive impact on school performance.

Previous Studies on Importance of Reading Practice

Two Institute studies, published in 1992 and 1993, together with a third published in 1996, documented that in-school reading practice is a curricular necessity if all students are to develop into competent readers.[1] The 1996 study, titled *Patterns of Reading Practice*, was by far the largest ever to address the subject, with data on 659,214 K-12 students. Its results are compelling evidence that schools should devote far more class time — as much as an hour per day, from the first day of kindergarten to the last day of high school — to reading practice. (By contrast, students currently spend only seven minutes per day in reading practice. High school students average only two to four minutes per day, about the same amount of time as kindergartners.) One finding was that higher levels of reading practice correlated to higher achievement not only in reading but in math as well, suggesting that strong reading skills are a foundation for all other academic achievement.

A Brief Introduction to the Accelerated Reader

The Accelerated Reader is a system of computerized testing and record-keeping. Its goal is to increase literature-based reading practice. This goal dovetails with the findings of *Patterns of Reading Practice*, that the more students read, the better they perform on academic achievement tests in both reading and mathematics.

The program includes a list of more than 12,000 books, each of which has a reading level calculated according to a widely-used readability index.[2] Each book is also assigned a maximum "AR Point Value," derived from its length and reading level according to the following formula:

$$AR\ Points = (10 \times Reading\ Level) \times \frac{(\text{Words In Book})}{100{,}000}$$

The procedure for the student is:

1. Select a book from a list.

2. Read the book.
3. Go to the computer and take a multiple-choice, objective test about the book.

The test takes the place of book reports and other evaluation tools, assuring the teacher that the student has read the book. The program awards the student AR points equal to the percentage test score times the book's AR Point Value, provided that the student scores at least 60 percent on the test. The combination of test scores and points earned gives teachers a quick, efficient way to track student achievement, enabling timely, effective intervention when indicated. AR provides 21 different reports for teachers, students, and parents.

Previous Studies on the Accelerated Reader

As indicated above, there is abundant anecdotal evidence that use of the Accelerated Reader gets students to read more books, and that scores on standardized tests rise accordingly. There have been four small-scale independent studies that lend support to the anecdotes.[3] Two of these reports include control groups: Peak & Dewalt (93), and Vollands, Topping & Evans (96). These two controlled studies are summarized below:

Peak and Dewalt

In February 1993, Professor Mark W. Dewalt and Janie Peak published the results of a five-year longitudinal study conducted at two schools in North Carolina: Cherryville Junior-Senior High School in Cherryville, and Grier Junior High School in Gastonia. Dewalt and Peak chose the two schools because they were similar in student populations, minority populations, and socioeconomic levels. They tracked a group of 25 students from each school over a five-year period, using mean CAT reading scores from third-, sixth-, and eighth-grade cumulative records. The mean score for the Grier students was 736 when they were tested in third grade. Their score rose to 767 in sixth grade, and then to 775 in eighth. Meanwhile, the Cherryville students started at 726, then rose to 780, and finished at 797.

The Cherryville students, who used the Accelerated Reader for all five years of the study, improved their mean score by 18 points per year over the first three years, and 8.5 points per year over the second two years. The Grier students, who did not use the Accelerated Reader, saw mean improvements of only 10.3 and 4.0 per year over each of the test periods.

These numbers strongly suggest that use of AR helps children become better readers. Nonetheless, there may be factors that exaggerate the effect. For

example, Cherryville is a somewhat smaller school serving a more rural population than Grier: We do not know how this may have affected the results. Similarly, Cherryville may have teachers who are more dedicated to the literature-based reading approach that AR is intended to facilitate.

Vollands, Topping and Evans

The most recent study of which we are aware was performed under the direction of Professor Keith Topping of the Centre for Paired Learning, at Dundee University in Scotland. This two-part study contrasted the Accelerated Reader first with a standard school curriculum, and also with a labor-intensive alternative teaching method. The study measured student reading scores and attitudes toward reading, before and after several weeks in each of the above-mentioned programs.

The two parts of the study were conducted in different schools using different students both for the AR group and the control group. Part A included 27 AR students and 12 control students, while Part B compared 24 students in the AR class with 26 students in the alternative class.

Both parts of the study suffered problems with the implementation of AR. Teacher training and book availability were limited by a lack of resources. Early in the program, students tended to read too many books too quickly, using up the available supply without deriving the maximum benefit. Had the teachers been fully trained, one expects they would have intervened to correct this.[4] Moreover, this may be a general concern — that it takes a certain amount of time for students to become familiar with the system, and to understand how to work within it. This is an effect that must be planned and accounted for if one is to perform a successful study.

Despite difficulties with implementing the Accelerated Reader in a short time, the Dundee researchers observed that use of AR gave significantly better results than the standard method, and was at least as effective as the more costly alternative method.

The Data

This study is based on data collected by the Texas Education Agency (TEA) in the spring of 1995. We chose Texas for several reasons:

- Texas is a large, diverse state with demographics representative of the entire U.S.
- Of states having comprehensive testing, Texas is one of the few of which we know that makes data available electronically.

- Texas provides a socioeconomic ranking for its schools, enabling us to establish control groups.
- Texas has a high percentage of schools owning the Accelerated Reader (more than 40 percent).

Demographically, Texas is reasonably analogous to the nation as a whole. It has a slightly more urban population (about 80 percent, versus 75 percent for the nation),[5] and a slightly more racially diverse population (about 25 percent non-Caucasian, vs. 20 percent for the nation).[6] Since these percentages are both increasing nationally, however, Texas probably represents national demographics a few years into the future. Texas also has a higher percentage of persons living below the poverty line (18 percent vs. 13 percent), but as we shall see, our study accounts for the socioeconomic status of students on a school-by-school basis.

In keeping with a legislative mandate, TEA annually conducts a comprehensive criterion-referenced test, the Texas Assessment of Academic Skills (TAAS). The tests are given in the 3rd through 8th grades, and in the 10th. All Texas schoolchildren in these grades take the test; some elements are administered to every grade, and others only at certain grades. One of the agency's goals for the test is that it "include only those items judged to be free of gender, ethnic and/or cultural bias, and deemed acceptable by the educator review committees."[7] More particularly, the test is intended to reliably assess both basic skills and higher-order thinking skills. Toward that end, TEA has implemented an exhaustive procedure of quality control, based both on statistical methods and oversight by interested parties. The tests are normed using cumulative data from the 1990 administration of the test, involving millions of students.[8]

Texas makes individual schools' pass rates for the TAAS available electronically, facilitating large-scale statistical analysis. Thus, other researchers would be able to replicate this study.[9] Texas also has developed a scheme for placing schools on a socioeconomic continuum, in which a campus' rating derives from a weighted average as follows:[10]

Weight	Factor
(35 percent)	Percent Economically Disadvantaged
(35 percent)	Percent Minority
(12 percent)	Percent Limited English Proficiency
(12 percent)	Percent Mobility
(6 percent)	District Wealth
(100 percent)	Socioeconomic rating

Using this scale, researchers can compare any school to a control group made up of schools with similar ratings. TEA defines a school's peer group to be the 100 schools nearest it on the scale.

For our purposes, we needed to compare each of Texas' 2,511 AR schools (those which own the Accelerated Reader) with a control group of non-AR schools (those which do not). By cross-referencing Advantage Learning Systems' database of AR owners with the TEA database, we were able to identify 80 to 100 peers for each AR school.[11] We then created a control peer group for each AR school by selecting only its non-AR peers. The resulting control groups generally contained 40-60 schools.

We also used data collected by Quality Education Data, Inc., which sells data primarily for marketing purposes. By linking QED's database with the TEA and ALS data, we were able to compare AR's effectiveness in different categories of schools, such as those with many computers versus those with relatively few, and to search for potential biases in our sample.

The Study

The study started with the hypothesis that the Accelerated Reader has no effect on TAAS scores or attendance in Texas schools (the so-called "null hypothesis"). From this perspective, one assumes any observed correlation between AR ownership and scores or attendance is likely to have occurred by chance. If the null hypothesis fails to hold, we may then ask whether the effect is explained by some other characteristic of the data. We identified six particularly informative analyses:

1. Comparison of pass rates at AR schools with median pass rates of their non-AR peers
2. As above, but broken out by years of AR ownership
3. As above, but broken out by metropolitan status
4. As above, but broken out by Orshansky socioeconomic status
5. As above, but broken out by ratio of microcomputers to students
6. Comparison of attendance rates at AR schools with median attendance rates of their non-AR peers

1. From the available TEA data, we chose 30 test-score categories for analysis. The categories include data from grades 3 through 8, as well as grade 10. The test for each category was the same: Count the number of AR schools whose pass rate in that category was above the median pass rate for that particular school's

peer cohort, as described earlier. If AR has no effect on pass rates, we would expect that about half of all AR schools would score above their cohort's median, and about half would score below. We can evaluate discrepancies from this expectation by calculating a Z-value according to this formula:[12]

$$Z = \frac{(\text{n Above Median} - 0.5) - 0.5\,(\text{N} - \text{n At Median})}{0.5\sqrt{(\text{N} - \text{n At Median})}}$$

The higher the derived Z-value, the less likely it is that observed discrepancies are the result of chance; *i.e.*, the more likely it is that the observations are due to real effects of owning the Accelerated Reader.

The categories included reading, math, and overall pass rates for each of the grades tested. Other categories included pass rates for the writing test administered in fourth, eighth and tenth grades, and the social studies and science tests administered in eighth grade. The final categories were cumulative across all grades for reading, math, and overall pass rates, and across grades 4, 8, and 10 for the writing test pass rates.

2. We performed a similar analysis to that in part 1, except that we divided the AR schools into four classes:

A. Owned AR for less than 1 year;

B. Owned AR for 1 - 2 years;

C. Owned AR for 2 - 3 years;

D. Owned AR for 3 or more years.

We then calculated the number of AR schools in each of these classes that had performed above the median of their cohort in overall pass rates, in all grades, and calculated Z-values as described above. We also performed chi-square tests across the categories to evaluate the significance of any differences observed.

3. Exactly as in part 2, except that AR schools were divided according to their metropolitan status (urban, suburban, rural), identified via the QED database.

4. Exactly as in part 2, except that AR schools were divided into three groups according to their Orshansky socioeconomic status (SES), as provided by QED.[13] Schools with Orshansky ratings less than 36 were grouped as high SES; those rated 36 to 51 were considered as medium SES; and those rated above 51 were labeled low SES.

5. Exactly as in part 2, except that AR schools were divided into three groups according to their ratio of students to microcomputers (high: 1-9 students per

computer; medium: 10-19 students per computer; low: 20 or more students per computer). Again, these data were obtained from QED.

6. Our interest in attendance rates was motivated in part by informal reports from teachers and school administrators, observing that use of AR seemed to improve attendance. Since TEA provides suitable data, we included this in our study. Among those schools for which attendance data were available, we performed a similar analysis to those above, counting the number of AR schools whose attendance was above the median for their socioeconomic cohort, and then calculating a Z to measure the statistical significance of any deviation from the expectation that about half of AR schools would be above the median and about half would be below it.

Results

The results of this study lead us to reject the null hypothesis; that is, AR schools show a statistically significant tendency to perform better on the TAAS than do their non-AR peers. Moreover, our analysis fails to identify any biases in the data that would account for this observed tendency.

In almost every category, Z scores showed a statistically significant number of AR schools having higher pass rates than their peers. Generally, 52 percent to 58 percent of AR schools in a given category scored above their cohort's median.[14] In most categories, Z scores indicate a statistical significance at a level of 1 percent or better; *i.e.*, there is a less than 1 percent chance that an effect of this magnitude would arise simply by chance. Notable exceptions were scores for sixth-graders and tenth-graders, which showed no significant effect of AR ownership. Possible explanations for this are given in the discussion following the results of all six parts.

Table 1

Use of AR Improves TAAS Pass Rates in Most Cases

Comparison of Texas AR Schools' TAAS Pass Rates With the Median of Non-AR Peers

Comparison	#AR Schools With Pass Rate Below Median	#AR Schools W/ Pass Rate At Median	#AR Schools W/ Pass Rate Above Median	N	Proportion Above Median	Z
All tests, 3rd grade	685	7	818	1510	0.54	3.40
Reading test, 3rd grade	705	13	793	1511	0.53	2.25
Math test, 3rd grade	715	5	791	1511	0.53	1.93
All tests, 4th grade	689	10	794	1493	0.54	2.70
Reading test, 4th grade	648	13	830	1491	0.56	4.71
Math test, 4th grade	708	4	780	1492	0.52	1.84
Writing test, 4th grade	699	4	790	1493	0.53	2.33
All tests, 5th grade	632	4	692	1328	0.52	1.62
Reading test, 5th grade	616	11	701	1328	0.53	2.31
Math test, 5th grade	621	2	705	1328	0.53	2.28
All tests, 6th grade	417	2	419	838	0.50	0.03
Reading test, 6th grade	416	6	416	838	0.50	-0.03
Math test, 6th grade	420	2	416	838	0.50	-0.17
All tests, 7th grade	298	4	355	657	0.54	2.19
Reading test, 7th grade	294	7	356	657	0.55	2.39
Math test, 7th grade	289	1	367	657	0.56	3.01
All tests, 8th grade	274	2	378	654	0.58	4.03
Reading test, 8th grade	282	7	368	657	0.57	3.33
Math test, 8th grade	280	3	372	655	0.57	3.56
Writing test, 8th grade	278	1	378	657	0.58	3.87
Social studies, 8th grade	288	3	366	657	0.56	3.01
Science, 8th grade	304	2	351	657	0.54	1.80
All tests, 10th grade	142	2	138	282	0.49	-0.30
Reading test, 10th grade	146	1	135	282	0.48	-0.72
Math test, 10th grade	140	2	139	281	0.50	-0.12
Writing test, 10th grade	132	1	149	282	0.53	0.95
All tests, grades 3-8 & 10	1136	15	1360	2511	0.54	4.46
Reading, grades 3-8 & 10	1144	17	1350	2511	0.54	4.10
Math, grades 3-8 & 10	1131	15	1365	2511	0.55	4.66
Writing, grades 4, 8 & 10	1073	7	1245	2325	0.54	3.55

Z score of 1.65 is statistically significant at 5 percent level.
Z score of 2.33 is statistically significant at 1 percent level.

The statistics favor the AR schools in all subject areas: Reading, math, writing, social studies and science. In the case of seventh-graders, the effect was slightly more pronounced on math scores than on reading scores.

The weight of the cumulative data leaves no doubt. When summing across all grades, we see gains for AR schools in reading and in math, with 54 to 55 percent of AR schools performing above their peers' median. The Z scores for these categories (4.10 and 4.66) indicate near certainty that the effect is real.

Table 2

TAAS Pass Rates Improve the Longer AR at School

Comparison of Texas AR Schools' Pass Rates With the Median of Non-AR Peers By Years of Use.

Comparison	#AR < Median	#AR at Median	#AR > Median	N	Proportion Above Median	Z
All tests, grades 3-8 & 10 Owned AR < 1 year	408	5	395	808	0.49	-0.49
All tests, grades 3-8 & 10 Owned AR 1 - 2 years	346	3	420	769	0.55	2.64
All tests, grades 3-8 & 10 Owned AR 2 - 3 years	185	1	263	449	0.59	3.64
All tests, grades 3-8 & 10 Owned AR 3 or more years	197	6	282	485	0.59	3.84
Totals:	1136	15	1360	2511	0.54	4.46

Analysis of all scores over all grades shows that AR has no significant effect on test results during its first year of ownership. (AR schools actually performed somewhat below the median, but with no statistical significance.) There is a substantial gain during the next year, and once more the following year. At this point the effect appears to stabilize. Schools that have owned AR for 2 or more years are 59 percent likely to have pass rates above the median for their control group. We calculated a Chi-square value of 16.05, which indicates a p-value <0.005.

Table 3

AR has greatest impact on urban schools

Impact of AR on TAAS Pass Rates by Metro Status

All tests, grades 3-8 & 10	#AR < Median	#AR at Median	#AR > Median	N	Proportion > Median	Z
Metro Status = 1 (Urban)	379	2	540	921	0.58	5.2779
Metro Status = 2 (Suburban)	468	12	524	1004	0.52	1.7463
Metro Status = 3 (Rural)	289	1	296	586	0.50	0.2481
Totals:	1136	15	1360	2511	0.54	4.4636

Analysis of AR's relative effectiveness in different metropolitan settings indicates that AR is by far most influential in urban, rather than rural or suburban schools. Fifty-eight percent of urban AR schools had pass rates above their cohort's median, with a Z value of 5.28. Fifty-two percent of suburban AR schools were above average, while rural schools showed no statistically significant difference in pass rates. Chi-square analysis of these differing effects gave a result of 11.6 ($p < .005$).

Table 4

AR Has Greatest Impact on Low SES Schools

Impact of AR on TAAS Pass Rates by SES

All tests, grades 3-8 & 10	#AR < Median	#AR at Median	#AR > Median	N	Proportion Above Median	Z
Orshansky = 0-35 (upper)	355	4	415	774	0.53	2.1262
Orshansky = 36-51 (middle)	467	7	484	958	0.50	0.5188
Orshansky = 52-99 (lower)	314	4	461	779	0.59	5.2445
Totals:	1136	15	1360	2511	0.54	4.4636

Analysis of AR's relative effectiveness in different socioeconomic settings indicates that AR is most useful in low SES environments. Fifty-nine percent of low SES schools (52 <= Orshansky <= 99) had pass rates above their cohort's median, with a Z value of 5.24. Chi-square: 12.9 ($p < .005$).

Table 5

AR Is Effective Regardless of Computer Availability

Impact of Computer Microdensity on TAAS Pass Rates

All tests, grades 3-8 & 10	#AR < Median	#AR at Median	#AR > Median	N	Proportion Above Median	Z
Microdensity = low 20+ students per computer	222	3	267	492	0.54	1.9897
Microdensity = medium 10-19 students per computer	437	8	518	963	0.54	2.5887
Microdensity = high 1-9 students per computer	477	4	575	1056	0.54	2.9906
Totals:	1136	15	1360	2511	0.54	4.4636

Analysis indicates that AR is effective regardless of the relative availability of microcomputers within the school. Having categorized schools as having 20 or more students per computer, 10 to 19 students per computer, or 1 to 9 students per computer, we found that in each group, 54 percent of AR schools placed above the median TAAS pass rate of their TEA peers. Chi-square: 0.14 (not significant).

Table 6

AR Improves Attendance

Comparison of Texas AR Schools' Attendance Percent With the Median of Non-AR Peers

Comparison	#AR < Median	#AR at Median	#AR > Median	N	Proportion Above Median	Z
Campus attendance rate	343	47	540	930	0.61	6.60

The largest effect of any discovered in this study was that which AR appears to have on attendance. Sixty-one percent of AR schools showed higher attendance rates than the median of their peer controls. Although there was a smaller sample than in other parts of the study, because of limited data availability, the Z value for this result was nonetheless 6.60.

Discussion

Significance of results

Despite the significance indicated by the high Z values, one might be tempted to dismiss these results because of the relatively low magnitudes of the effects observed. *It is important to understand that we are wielding a rather blunt statistical instrument.* In a sense, we have set up a detector at the passing score of each test, and we detect only students who cross that line due (we hypothesize) to their schools' usage of AR.[15] We know nothing else about their scores, nor those of their classmates. Given this constraint, our observation of statistically significant results suggests that there is an iceberg of other effects that we cannot measure.

In particular, Paul (92) observed that the greatest effect of additional reading practice is on those students with the lowest reading ability. Such students may be earning much higher scores at AR schools than at non-AR schools, but we will not observe them unless their improvement pushes them across the pass threshold — a comparatively unlikely event given their starting point. Thus, for every raised score we detect, there should be many, many more that we cannot observe.

Similarly, we observed no significant effect for AR in rural schools. However, the median overall pass rate for third through fifth grades was 68.2 for rural AR schools versus 63.5 for urban AR campuses. One implication is that the urban schools had more room for measurable improvement, because they had a larger percentage of students who could conceivably "pass through" our detector.

Eliminating bias concerns

The results of Part 1 clearly demonstrate a correlation in the data between AR ownership and higher test scores; thus, we reject the null hypothesis. However, a critic may suggest alternatives to the conclusion that AR *causes* these higher test scores. In particular, we must look for potential sources of bias in the data.

Self-selection bias

One might argue that because AR schools have a presumed bias towards emphasizing reading skills — otherwise, why would they buy the software? — these schools would do better whether or not they owned the software. The results of Part 2 tend to refute this. The relationship between length of ownership and observed effect is important because it tells us that this self-selection bias does not compromise our other results. AR schools do no better than their peers until they have had time to implement the software into their curriculum.

Indeed, although we present further analyses that eliminate other bias concerns, this one result is the most telling. If there were any particular characteristic that

made a school more likely to own AR, and that similarly made that school more likely to perform well on the TAAS, we would expect first-year AR schools to show above-average results. They do not.

Rural/urban bias

One might argue that AR schools are likely to belong to a metropolitan category that performs better than its socioeconomic peers. However, we found that 38 percent of all Texas schools fall into our urban classification, while 37 percent of Texas' AR schools do.[16] Our AR sample is slightly biased towards suburban schools (40 percent, versus 38 percent for all of Texas), which should not cause significant variations in our results.

Technology bias

One might also argue that since AR schools are more likely to own computers, they are also more likely to be taking advantage of other software that contributed to the apparent effect of AR. Our data do not support this claim. As shown in Part 5, we observed no relationship between the ratio of computers to students and the apparent effectiveness of AR.

Socioeconomic bias

This potential source of bias is primarily addressed by the use of the TEA control groups. As observed above, we ran hypothesis tests to assure that the TEA groups are indeed statistically unbiased with respect to pass rates.

One other source of bias

The major bias in this study should attenuate, rather than exaggerate, the observed effects of AR. This bias occurs because we classify any school that owns AR as being an AR school, although we do not know to what extent they are using the software; indeed, we do not know whether they are using it at all. In our analyses, a school in which one of ten English teachers uses AR, perhaps with selected classes or populations, has equal weight with an AR school in which AR is used in all classes by all students in all grades. The result of Part 2 is strong evidence that this will bias the study towards the null hypothesis, since schools that own the program but haven't yet had time to use it show no significant improvement over the performance of their control groups. From this perspective, the recent success of AR in Texas schools works against it: almost one third of the AR schools bought the software during the year the data were collected. The simple expedient of removing these schools from the sample altogether would have pushed the results much further in favor of AR's usefulness. Including them as non-AR schools would have been even more dramatic in its effect on the numbers. To claim that there is no causal relationship between AR ownership and higher pass rates is to assert that somewhere in the data lurk unknown biases that are powerful enough to overcome this huge negative bias.

The Biggest Benefit

The results of Part 4 indicate that AR has its strongest effects in schools at the low end of the socioeconomic scale. More precisely, we observe that AR schools with low socioeconomic ratings are more likely than any others to outperform their non-AR cohorts.[17] We may infer from this the group of students most likely to benefit from AR: Socioeconomically disadvantaged children. This corresponds to our general understanding. We know[18] that children in these schools are least likely to come from homes where reading is a valued activity, and that such children are similarly least likely to become readers themselves. They thus have the most to gain from an instructional tool designed to motivate reading.

Anomalous Results

As noted above, AR schools showed no statistical difference from their non-AR cohorts for tests in sixth and tenth grades. We can offer some explanations for these observations.

Since many students switch from one elementary school to a different middle school at sixth grade, we expect that a shuffling will happen in which some students move from AR campuses to non-AR campuses, and vice versa. Because we are dealing with snapshot data, there is no way for us to track these students. This blurring of student groups is itself enough to explain the anomalous result; however, we also know (as demonstrated in Part 4) that the longer a school owns AR, the better that school's scores are likely to be. It may be that part of the advantage lies with the students' familiarity with the AR system. As noted earlier, Vollands *et al* (96) observed that when first introduced to AR, students tend to read too many books too quickly.

The anomaly in 10th grade may simply be that although these schools own AR, they do not use it to any great extent. Our observation is that high schools typically use AR in a limited way, often for remedial purposes or as an optional supplement to the regular English curriculum. As noted above, lack of usage data inherently biases this study towards the null hypothesis.

Attendance

Overall, the data leave little doubt about the influence AR can have in schools. Of all the results provided, none is so telling as that concerning attendance. To the extent that students who are successful in school are more likely to go there, if AR did nothing but give children one subject in which they considered themselves competent, we believe it would make them more likely to attend. We can identify several direct ways in which AR motivates students to attend school:

- Must attend to take the tests.

- Facilitates social benefit of reading; *i.e.*, discussions with peers about books one has read.
- School library has the books.

These first-order effects will inevitably influence a host of higher-order patterns. Here is a list of some possible causal relationships:

- Success in reading motivates students to attend; increased attendance brings success in other subjects.
- Success in reading raises self-esteem; increased self-esteem motivates students to try harder in other subjects; trying harder brings success in other subjects.
- Success makes students better readers; being better readers lets them understand texts in other subjects.
- Success in reading improves students' cognitive skills; improved cognitive skills help students learn other subjects; etc.

Conclusions and Policy Implications

The data show that schools with AR outperform their peers on standardized tests in all subject areas. They do not measure the effect size, largely because of the inability to gauge AR usage, but the implication is that AR is more influential — possibly much more so — than these analyses can demonstrate. One might note the small magnitude of the effect (54 percent above the median, versus 50 percent expected) and dismiss the results as too small to be important. This would be an inappropriate interpretation. As the discussion above makes clear, the study is strongly biased against showing a positive result for AR. For schools owning AR more than two years, the figure is 59 percent above the median; and this still does not take into account the degree to which AR has been implemented.

It is beyond the scope of this study and of the currently available data to discover more precise and useful relationships, such as the likelihood that a student who would otherwise fail a particular TAAS test would instead pass if the student's school included AR as part of a fully implemented curriculum of literature-based reading practice. We hope that in the future, automated data-collection techniques embedded within products such as the Accelerated Reader and S.T.A.R.™ (a computerized reading assessment system released by ALS in fall of 1996) will enable more sophisticated and precise measurements of the effectiveness of instructional tools and techniques.

Nonetheless, together with the results of *Patterns of Reading Practice* (as well as other previous Institute studies) showing the value of reading practice in improving overall academic achievement, it is reasonable to assert that AR is an effective tool in stimulating increased reading, and that increased reading will lead to higher attendance rates and greater academic success.

Not incidentally, these benefits will accrue primarily to those who need them most: socioeconomically disadvantaged children living in urbanized areas. This fits well with the concept of value-added education: Achieving results where they make the greatest difference.

We can project many benefits beyond the obvious economic opportunities that come with academic success. Children who read literature understand that there is a world beyond the immediate horizon (or concrete wall); that their own circumstances do not necessarily represent normalcy; that there are values and possibilities more uplifting and universal than those found on the street; and that there is something called morality which we must all address in our choices of how to live.

Notes

1. Paul, T. (1992). *1992 National reading study and theory of reading practice.* Madison, WI: The Institute for Academic Excellence. Paul, T. (1993). *National study of literature-based reading: How literature-based reading improves both reading and math.* Madison, WI: The Institute for Academic Excellence. Paul, T. (1996). *Patterns of reading practice.* Madison, WI: The Institute for Academic Excellence.

2. Since January 1994, Advantage Learning Systems, the publisher of the Accelerated Reader, has used an automated program which utilizes the Flesch-Kincaid reading index to determine readability. See Flesch, R. (1974), *The art of readable writing with the Flesch readability formula.* New York: Harper & Row; and Kincaid, J.P., et al. (1981, March). (Computer reading ability editing system, *TEEE Transactions on professional communications.*) Prior to 1994, Advantage Learning Systems used the Fry Readability Index. See Fry, E. (1968). "A readability formula that saves time." *Journal of Reading*, 11, 513-516.

3. Peak, J. & Dewalt, M. (1994). "Reading achievement: Effects of computerized reading management and enrichment." *ERS Spectrum*, 12:31-34.

Turner, T. (1993). *Improving reading comprehension achievement of sixth, seventh, and eighth grade underachievers.* Nova University.

McKnight, D. (1992). *Using the Accelerated Reader and other strategies and varied techniques to improve the reading attitudes of fifth grade students.* Nova University.

Vollands, S., Topping, K., & Evans, H. (1996). *Experimental evaluation of computer assisted self-assessment of reading comprehension: effects on reading achievement.* Presented at the National Reading Research Center Conference on Literacy and Technology, October 4, 1996, Atlanta, Georgia.

4. Recall that students can only get points for books for which AR includes a test. Moreover, students may only test once for a given book. If students read too quickly, they score poorly because they aren't reading with comprehension. When implemented according to design, teachers oversee students' reading patterns, and if their test scores are too low, intervene with advice on reading level and rates.

5. *The sourcebook of ZIP code demographics*, Vol. 1. (309-A) (1992). Arlington, VA: CACI Marketing Systems.

6. *The sourcebook*, (307-B).

7. *Texas student assessment program technical digest for the academic 1994-95* (1995). Austin: Texas Education Agency.

8. *Texas student assessment program* Chapter 8.

9. Advantage Learning Systems will make available its Texas customer list on a confidential basis to qualified researchers who may wish to validate the study results.

10. The unidimensional ranking for a school is a group index calculated in three steps: First, a standard Z score is computed for each of the five demographic variables, reflecting the significance of that variable for the particular school; second, these standard scores are multiplied by their weights as shown in the table in the text; finally, these values are summed to provide the school's group index.

- Economically Disadvantaged students are those eligible for free/reduced-price lunch or other public assistance.
- Minority students are non-white (African American, Hispanic, Asian, Pacific Islander, Native American).
- Limited English Proficient are those identified by the Language Proficiency Assessment Committee or designated professional.
- Mobile students are those who have been in membership at the school for less than 83 percent of the school year.
- District Wealth is a ranking from 1-10 based on the ratio of total taxable property value to the number of students in the district.

11. To demonstrate that the TEA defined control groups are unbiased with respect to TAAS performance, hypothesis tests were run for each of the 30 test and test-composite pass rate categories for which data are provided on the TEA WWW server. None of these comparisons were statistically significant in their deviation from the expectation that 50 percent of the schools would have pass rates higher than the median of their control group, and 50 percent would have pass rates that were lower.

12. Daniel, W. (1990). *Applied nonparametric statistics, second edition*. Boston: PWS-KENT Publishing Company. Chapter two discusses the "One-sample sign test" technique, including the use of the normal approximation to the binomial to generate p-values.

13. Orshansky Percent is the number of students below the federal poverty line, given as a percentage of all children within the district's boundaries.

14. Note that calculation of the proportion above/below the median does not incorporate campuses at the median. This is consistent with the calculation of the Z-statistic, which specifically measures the likelihood of a given distribution

above and below the median occurring due to chance, with events at the median being ignored. See note 12 for references on the Z-statistic.

15. We must emphasize that this is a metaphor. We cannot know whether any individual student would or would not have passed any particular exam, regardless of AR ownership at school.

16. We found that rural AR schools had higher mean pass rates than urban AR schools, yet in many categories they were significantly likely to have pass rates below the median for their non-AR peers. One explanation is that with socioeconomic factors held equal, urban schools in general may outperform rural schools.

17. Some of this effect is due to our technique. Low-SES schools generally have lower pass rates (e.g., for AR schools, mean pass rates on third-, fourth- & fifth-grade reading tests were 73 percent for low-SES versus 86 percent for high-SES campuses). Thus, low-SES schools have more students who can potentially improve and cross the pass line.

18. Watkins, M. & Edwards, V. (1992). "Extracurricular reading and reading achievement: the rich stay rich and the poor don't read." *Reading Improvement*, 29, 236-242. Goodlad, J. (1984). *A place called school*. New York: McGraw-Hill.

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